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THE IMPORTANCE OF WATER  
TO INDUSTRY IN  
SOUTHERN CALIFORNIA

By  
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**I**T IS a pleasure to discuss with you the importance of water to industry in Southern California.

As a member of the American Institute of Mining Engineers and of the American Association of Petroleum Geologists, I find in studying your program that you are discussing many of the subjects which we discuss as petroleum and production engineers in our meetings of the Institute.

Water and oil both occur in the earth. Many of the laws of nature affecting one, apply equally with regard to the other. Water sells for two and a half to five cents per ton as you buy it through your water meter. Crude oil sells for one cent per pound, while milk retails at ten cents per pound. Because of the greater value of the oil which we produce, as compared with water, the oil industry spends a lot more money to establish geological facts than the water industry can afford.

Next to the air we breathe, the water we drink is the most important thing in our lives. Water is taken for granted by many people, so much so that we have the expression, "We never miss the water until the well runs dry." Had that been entirely true, there would be no Southern California as we know it today. This community has been fortunate in the leadership and the public support which that leadership has been given in providing water for the future. Not a single major water development, involving the expenditure of large sums of public money, has occurred in the past fifty years except with the prior consent of more than fifty per cent of the voters of the community involved. Our leadership in water matters has been so very successful because of intelligent understanding of the problem by all parts of the community.

Later, I will discuss some phases of the water side of this subject, but I would like to tell you a little about the industrial side at this time. Industry here is now of national importance. Areas of this country are classified according to the name of the principal city and so the

Los Angeles Metropolitan Area includes all of Los Angeles County and Orange County. Of the five principal Metropolitan Areas of the United States, Los Angeles is third—these areas being New York, Chicago, Los Angeles, Detroit, and Philadelphia.

The value added by manufacture in New York and Chicago is still substantially greater than that for the next three Metropolitan Areas. In manufacture Los Angeles also exceeds Pittsburgh, Cleveland, and Boston Metropolitan Areas and is more than double that of the Metropolitan Areas of St. Louis and San Francisco.

The Los Angeles Metropolitan Area ranks first in the nation in the following industries:

- Aircraft and Aircraft Parts
- Motion Picture Production
- Pumps and Compressors
- Canned Sea Food
- Heating and Pumping Equipment

It ranks second in the nation in the following:

- Transportation Equipment
- Women's Clothing
- Pressed and Blown Glass
- Concrete and Plaster Products
- Automobile Assemblies
- Automobile Tires and Tubes
- Storage Batteries
- Jewelry and Silverware
- Millwork in Wood
- Oil Field Machinery and Tools

It ranks third in the nation in the following:

- Newspaper Publishing
- Petroleum Refining
- Pottery and Related Products
- Non-ferrous Foundries
- Construction Equipment
- Conveyor Equipment
- Rubber Industries
- Apparel Industry
- Venetian Blinds

All of the romantic literature of New England authors would make you think that New



England is the center of the fishing industry, but 32 per cent of the canned sea food of the United States is produced right here in Southern California. Other percentages of national production of major interest are:

Aircraft—43 per cent

Aircraft and Parts—32 per cent

Oil Field Machinery and Tools—22 per cent

Auto Trailers—20 per cent

Truck Trailers—14 per cent

Floor and Wall Tile—13 per cent

Leather and Sheep Lined Clothing—12 per cent

Petroleum Refining—8 per cent

Petroleum Production—7 per cent

Women's Apparel—from 5 to 7 per cent

Furniture—from 5 to 7 per cent

Agriculture is also an important industry. Los Angeles County has been either first or second in the value of its agricultural production for many years. It is interesting, however, to point out that changes are occurring here. We think of the citrus industry as being first in agriculture, but the value of dairy products, alone, in Los Angeles County is almost three times that of oranges and lemons combined.

The annual value of our agricultural products is more than half a billion dollars, but the value each year of our industrial products, excluding agricultural and also new homes and other structures erected in this area, is now over four billion dollars. The construction industry in 1954 will create another billion dollars of homes, buildings, and factories.

At the turn of the century there were about 300,000 people in the five Southern Counties of California. At the present time it is estimated there are 6,471,000 people in this same area. This represents a twenty-fold increase. The growth has been particularly rapid since 1940. From 1950 to 1954, the growth has been at the rate of 274,000 people per year. This means that here in Southern California each year for the last four years we have had to

build homes and schools and furnish work for a new city equal in size to any one of the following:

Long Beach, California; Dayton, Ohio; Omaha, Nebraska; Providence, Rhode Island; or Richmond, Virginia.

Growth may not continue at this rate, but if any of the trends of growth of the past are a moderate index of what may occur in the future, it has been estimated that by 1975 to 1980 there will be approximately 10,000,000 people in the five southern Counties of California, namely, Los Angeles, Orange, Riverside, San Bernardino and San Diego.

All of these different industries mean jobs. The following represents the number employed in the Los Angeles Metropolitan Area, namely, Los Angeles and Orange Counties, during the year 1953:

Aircraft.....	163,080
Construction.....	121,529
Electronics.....	60,000
Machinery Mfg. (Except Electrical) .....	54,880
Electric Machinery.....	49,925
Fabricated Metals.....	47,946
Food and Kindred Products.....	44,807
Apparel.....	41,322
Communications.....	33,478
Petroleum Production and Refining.....	33,376
Primary Metals.....	26,817
Printing and Publishing.....	26,369

These leading Southern California industries invested \$191,086,362 of capital in new factories and expansion of existing facilities during last year.

With the aircraft industry employing so many people, you can well understand why the Los Angeles Metropolitan Area contributes 43 per cent of the aircraft production of the entire United States. This does not include the aircraft industry of San Diego County, which in itself is also enormous.



Our construction industry depends in part upon the number of new people who come into Southern California. They must be provided homes, but they must also be provided jobs.

It is a very thrilling thing to say that 54 per cent of the homes in Southern California are owned by the people who live in them. As we are going to have another three and a half million people here in Southern California in the next 20 to 25 years, the construction industry should continue to flourish.

The other industries which I have mentioned are all stable supporters of employment. Our own oil industry, furnishing the fuel and gasoline needed for power and transportation, can take care of all of California's wants for several years to come. The invasion of California's outlying markets by oil from other areas, such as Canada, the Rocky Mountains and Arabia will serve to make our supply last longer. Furthermore, crude oil now sells on a world wide market, so if there should be a shortage it will be brought here without difficulty. In addition to our own California supply of natural gas, pipe lines from Texas guarantee an ample supply of fuel, which thus far has been more beneficial to Southern California industry than it has to our own oil industry. This is because gas still sells as fuel at a lower price than fuel oil.

Other industrial areas do not have their fuel supply so close to hand. Therefore, money paid for fuel in such cases does not remain in those areas in the same way it does in the Los Angeles Metropolitan Area.

How much water does industry use? This, of course, varies from industry to industry. Water is measured in many units, but I am only going to use gallons, cubic feet per second, and acre feet. An acre foot of water represents a volume of water covering an acre for one foot of depth, and a million gallons represents 3.07 acre feet. This variation in usage is illustrated by the following tabulation for industries in Los Angeles City:

	acre feet per year
Union Oil Wilmington Refinery.....	4,603
North American Aviation .....	1,037
Los Angeles County General Hospital.....	1,023
Southern Pacific Railroad.....	1,013
United Piece Dye Works.....	905
Biltmore Hotel.....	859
Parklabrea Towers.....	767
Armour & Company.....	727

Expressed in daily averages, these usages vary from 12.6 acre feet per day to 2 acre feet per day, or from 4.2 million gallons to 650,000 gallons per day.

Water usage is commonly expressed in gallons per person per day. This varies from 90 gallons in large apartment houses to 120 to 130 gallons per day per person in homes.

Water usage is also expressed in gallons per person per day so as to include industrial usage. For Los Angeles City in 1953, this amounted to 165 gallons per person per day. Such data, however, do not take into consideration water which industries pump from the underground independently of their supply from the City. Roughly speaking, the industrial usage per person per day is about 40 gallons or about one-third of the usage per person in the home.

On the basis of 165 gallons per person per day, which would include industrial usage, an acre foot of water per year will support 5½ persons. The 165 gallons per person established in 1953 represents a drought period of long duration. Under more normal conditions of rainfall a lesser quantity would be proper. On the basis of 149 gallons per person per day, including industrial usage, an acre foot of water per year will support 6 persons.

The coastal area of the five Southern Counties of California have the following sources of present usage and potential water supply:



	ACRE FEET PER YEAR Present Use	Potential Supply
Mountain watersheds run-off used by direct diversion and regulated by reservoir storage.....	250,000	250,000
Water pumped from Underground basins-safe yield.....	600,000	600,000
Water pumped from Underground basins representing overdraft.....	300,000	—
Owens Valley-Mono County Aqueduct—City of Los Angeles.....	320,000	320,000
Colorado River Aqueduct of the Metropolitan Water District of Southern California (Net delivery in distribution area) .....	190,000	1,180,000
Totals, annual averages.....	1,660,000	2,350,000

	CUBIC FEET PER SECOND Present Use	Potential Supply
Mountain watersheds run-off used by direct diversion and regulated by reservoir storage.....	345	345
Water pumped from Underground basins-safe yield.....	830	830
Water pumped from Underground basins representing overdraft.....	420	—
Owens Valley-Mono County Aqueduct—City of Los Angeles.....	440	440
Colorado River Aqueduct of the Metropolitan Water District of Southern California (Net delivery in distribution area) .....	260	1,630
Totals, annual averages.....	2,295	3,245

From the foregoing tabulation it will be noted that the difference between the potential supply and the present usage of water is 690,000 acre feet. If we assume that an acre foot of water will take care of 5½ persons per year, then the 690,000 acre feet will supply water enough for 3,800,000 people. On the basis of 6 persons per acre foot per year, the potential supply would take care of 4,140,000 people.

Today, the six million people in the Metropolitan Water District and the economy of all Southern California are dependent upon Colo-

rado River water as a supplemental supply. Colorado River water is co-mingled with local supplies in varying amounts throughout the entire area. If this water were not available, more than a million or one-sixth of these people would be without water for their homes and for the industries where they work.

Mention has been made of the importance of agriculture. The land devoted to raising nuts and citrus crops in Los Angeles County has decreased nearly 50 per cent. It is obvious that newcomers, representing over half our present population, will occupy land now devoted to agriculture for homes just as in the past. The advent of Colorado River water in certain regions having a deficiency of water, such as Riverside and San Diego Counties, may result in an expansion of use for agriculture. The use of water by this expansion will be much less than the shrinkage due to industry and homes being built on agricultural land. While it will be difficult to estimate how much water will thus be released, it will be substantial so that it is safe to state that the use of water for agriculture is now declining. Water thus released will help to support more people than the 4,140,000 estimated above.

Another factor that will bear upon the use of water is the price at which it is sold. We still have too many mutual water companies who do not meter the water to their customers. This, of course, results in waste, but with higher prices, metering will follow and other forms of waste will be eliminated.

Based on the foregoing, it is estimated that an increase in population of three and a half million is expected in 20 to 25 years. Certain it is that our Colorado River water supply will take care of over four million more people, whether they come here in 20 or 30 or 40 years. As engineers, we know that new industrial projects are not undertaken unless they will pay out in a much shorter time.

The five sources from which Southern California secures its water are interesting and unusual. Most large cities and communities secure their water from surface streams or lakes.



In this area, however, only about an eighth of the water we use represents surface water recovered from mountain watersheds, a portion of which is used directly and the remainder is stored and then used as needed. More than half of our present usage is underground water. This underground water has been the mainstay and the original basis of the growth of Southern California.

If I took a glass and filled it about half full of water and then poured sand into the glass so that the level of the sand came to the top of the glass, there would be a definite overflow of water. However, about a third of the volume of the glass would be represented by the water remaining between grains of sand. All of our local supplies of underground water occur in underground basins in the same manner.

In Los Angeles and Orange Counties and parts of San Bernardino and Riverside Counties we have been particularly fortunate because these large underground basins extend to a depth of from 1000 to 2000 feet. The basins are not filled with sand, but they are filled with layers of sand that are separated from other layers of sand by impervious clay bodies. Major clay bodies prevent the migration of water from one sand body to another. Upstream some of these sand bodies come to the surface.

It must not be inferred that to get additional water all we have to do is to drill a little deeper. Near the mountains we come to the original formation of the mountains, but out in the center of the valley below a depth of 1000 to 2000 feet, the sand bodies do not contain fresh water, but contain brackish water and at greater depth they contain salt water.

Going back into geological history, there were several periods when this country was a region of heavy rainfall. The mountain streams and rivers were laying down bodies of sand filled with water and covering them with layers of clay. In the development of Southern California, the shallow sand bodies became the first source of water. The streams with their winter and spring runoff flooded the exposed upper ends of these sand bodies so as to refill

them with water. As water uses increased, overdrafts occurred. The deeper sand bodies that cannot be filled have now been tapped by the water driller so that such water once used will not be restored by streams. Such deep sand bodies can only be refilled through the wells which removed the original water.

This great water reserve has not yet been exhausted, but it is in a precarious condition due to the invasion of salt water near the ocean. One of our principal jobs for the future is to protect and refill the underground basins. Already, many things have been done for that purpose. Sewers operated by County Sanitation Districts and Los Angeles City protect this water from contamination.

In 1946 Los Angeles County adopted an ordinance to protect these underground waters from pollution and from any operation that threatened to pollute such water.

In 1949 the State of California passed a water pollution control law, vesting in Control Boards in different regions of the State the power to protect such underground water. While these matters have been under discussion for 25 years, it has only been during the last three sessions of the Legislature that laws were passed providing vehicles for financing the restoring of the underground water levels. We expect additional legislative authority in the future to this end.

I am happy to state that in all of this activity, the oil industry has not only participated but often has lead the way. Salt water produced with oil in many of our fields is transported to the ocean in pipe lines constructed by the industry at no public expense. Water from other fields is transported to the ocean through sewers. Where this is not possible the injection of waste water into salt water bearing sands and into oil zones to improve oil recovery is being done. Throughout the State the oil industry is cooperating with the Regional Control Boards to protect underground water. New industries that come here need not anticipate difficulty in dealing with these Boards, whose members are always eminent citizens, who



serve without pay. They understand both the industrial side of the problem as well as the community needs of protecting the water. Because these laws were sponsored by industry, they are receiving its support throughout the State.

A little more than 50 years ago, the existence and relative abundance of this underground water supply became generally understood. All that one had to do was to buy a tract of land, drill a water well, and go into the housing business, start a farm or operate an industry. With an apparently unlimited supply of water, there was no problem of storage or transportation. Five years ago there were about 600 water companies in Los Angeles County, but recently there have been a large number consolidated. Many small ones are weak financially and their pipe lines are old. Little concern was given to sewage because cesspools were constructed in the same area from which the water was pumped. Thus, much of the water which was taken from the ground was again returned to the ground. This same practice continues even to the present time, except that sewers now take the used water to the ocean, and storm drains and channels carry off the flood water.

The greatest increase in population in the last seven years has been in county territory north of Long Beach and south of Whittier. This great area, which we call the Central Basin, extending from the Los Angeles City limits eastward to the Orange County line, only voted to join The Metropolitan Water District of Southern California on September 21, just a week ago. The assessed value of the Central Basin is more than one billion dollars. The actual value is probably between two and a half billion and three billion dollars. As a result of this activity, water tables have been lowered until water is now pumped in the area north of Long Beach from a depth of 100 feet below sea level. The overdraft amounts to 100,000 acre feet per year. Fortunately, indeed, are those people living in the Central Basin that Colorado River water is made available to them.

For all areas of Southern California the overdraft amounts to 300,000 acre feet per year.

In 1907 the City of Los Angeles voted a bond issue to build the Owens Valley Aqueduct. This was a courageous project. It was necessary to build a railroad, a cement mill and go into forbidding country before highways, trucks, and automobiles were available. This supply was sufficient to take care of Los Angeles City until within the last few years. Now, all future growth of Los Angeles will be supported by water from the Colorado River Aqueduct.

The City of San Diego, not being able to use underground basins of water in the same manner as was possible in Orange and Los Angeles Counties, built and acquired several reservoirs. The growth of San Diego, however, has been so great that these local supplies are no longer sufficient.

The next step in securing adequate water supplies for Southern California was the construction of the Colorado River Aqueduct by The Metropolitan Water District of Southern California. The need for this water was first impressed upon the community in 1923 and 1924 by a drought.

In 1925 the City of Los Angeles voted a two million dollar bond issue for investigating the availability of water and routes for an aqueduct from the Colorado River. The idea, however, of creating The Metropolitan Water District of Southern California was developed in 1924 in an organization known as the Colorado River Aqueduct Association and was further discussed in 1925 in a report of a group of fifteen of the Los Angeles Chamber of Commerce, headed by Lucius K. Chase. The Metropolitan Water District Act was finally approved by the Legislature in 1927.

A bond issue for \$220,000,000 was voted in 1931 by 13 cities in Southern California. The Aqueduct was built during the years of the depression. Only \$180,000,000 of the authorized bond issue was used in the initial construction. The last \$15,316,000 of the authorized issue is to be expended for an expansion program now in progress.



The Owens Valley Aqueduct built by the City of Los Angeles is 250 miles long and is the exclusive property of the City. The Colorado River Aqueduct, built by the Metropolitan Water District of Southern California, pierces the Colorado River mountains and crosses deserts for 242 miles from the Colorado River near Parker to the terminal reservoir Lake Mathews. The main delivery line to Santa Monica and other major distribution lines, not including those now under construction, increases the total length of the Aqueduct to 457 miles. By way of comparison, should New York City go to Lake Erie via Albany for water, the distance would be 420 miles. Most of the Colorado River Aqueduct was built to full size but inverted siphons and pumping plants were not built to full capacity. At the present time the pumping capacity of the Aqueduct is being increased by adding two more pumping units at each of the five pump lift stations. The cost of the added pumps is about three times that of the first units installed during the 1930's.

The Colorado River Aqueduct will eventually deliver 1,180,000 acre feet of water each year in the local distribution area. In 1953 water for current usage amounted to 190,000 acre feet, but in addition 60,000 acre feet was used for storage in part in surface reservoirs, but mostly for discharging into the Santa Ana River in Orange County to refill the underground basins. This year water is being taken for this purpose not only by Orange County but also by Conservation Zone 1 of the Los Angeles County Flood Control District in southeastern Los Angeles County. In the 1954-1955 year the water used for this purpose in Orange and Los Angeles Counties alone will amount to over 100,000 acre feet. The total amount of money spent for purchasing water for this purpose from 1949 to the end of 1954 will approximate \$2,900,000 for about 280,000 acre feet of water.

As heretofore explained, the Aqueduct will bring enough more water to permit a growth in population in the five counties which it serves of over 4,000,000 people as well as the

industries necessary for jobs to support the workers and their families.

This Colorado River water has also played another important part in the industrial growth of Southern California. The Metropolitan Water District agreed to pay for 36 per cent of the firm power of Hoover Dam. Without its agreeing to pay for this power, contracts for the construction of Hoover Dam would have been delayed and might have been impossible. Upon the delivery of electrical power to Los Angeles from Hoover Dam in 1936 the largest reserve of unused power in America was in Southern California.

The policy of The Metropolitan Water District has been both fair and liberal. Many areas in Southern California deficient in water have been permitted to join the District upon terms even more favorable than those imposed upon themselves by the original 13 member cities. As a result there are now more than 60 cities in the District. When a new area joined the District, it was allowed 30 years in which to pay its annexation charges in equal annual amounts, including three per cent interest during the amortizing period. This three per cent interest rate was charged from 1949 to 1954, but future annexations will be charged four per cent because that is the interest rate of most of the outstanding bonds of the District.

If the areas whose applications are now pending join, the Metropolitan Water District will have a fund, composed of annexation charges to be paid by annexing areas, of approximately \$175,000,000 available for use in its future construction work. The yearly amounts thus made available will vary from \$6,000,000 downward. With such funds, money from the sale of the remaining authorized \$15,316,000 of bonds and other tax funds, the District hopes to complete its work without the need of any new authorization of bonds.

Untreated water is sold to member cities wholesale at \$10 an acre foot and softened and filtered water at \$20 an acre foot. Both of these amounts are less than the price at which it would be necessary to sell water if all costs



were paid by the sale of water, even assuming that the Aqueduct were operated at its full capacity from the beginning for the first forty years of its operating life.

Up to this time, the Metropolitan Water District has been a tax supported institution. Taxes thus far collected amount to \$215,000,000. The District has retired \$24,100,000 of bonds, leaving \$180,584,000 of bonds to be paid for in the next 40 years or less.

Tax money has also been used to establish a bond retirement reserve of \$18,000,000 for interest payments, for construction work and meeting the deficit of operating the aqueduct. For a long time to come, the District is going to be a tax supported institution. However, the tax bill is our own and not that of the Federal Taxpayer.

We seek to operate on the most economical basis. Our normal Staff of employees is approximately 280. We have now about \$40,000,000 of work under contract. This volume of work has been planned and engineered by the addition of only 120 employees.

The work changes now being done consist of adding 2 additional pumps to the existing 3 for lifting water at each of the five pumping plants and the expansion of the distribution system from Lake Mathews.

From Lake Mathews in Riverside County, an Upper Feeder line skirts the Foothills. A second feeder line is now being built down the Santa Ana Canyon to Orange County and eventually it will be continued westward so as to pass through Southgate and to deliver water westward to Inglewood and Culver City.

Metropolitan water was first delivered in San Diego on December 12, 1947. By September, 1949, the quantity of water which the City had in its reservoirs equaled the volume of water which had been purchased from Metropolitan. This is another way of saying that San Diego, with its population of about 400,000 people, by September, 1949, would have had no other water except that from Metropolitan.

San Diego now buys more water from Metropolitan than any other city. Santa Monica uses almost all Metropolitan water. Pasadena and Long Beach now receive about half their water from Metropolitan.

In a city, such as Long Beach, the maximum daily usage in hot weather is two and a half times the minimum. For periods of several months, the usage in summer is about twice that in winter. This means that when the District's lines are delivering water at their full capacity, these summer peaks must be taken care of by pumping from underground basins. That is one reason why refilling of underground basins in Los Angeles and Orange Counties is such an important problem.

If the areas now seeking annexation to the Metropolitan Water District finally join, the District's area will be 3200 square miles and its total population will be about 6,000,000 people, while the assessed valuation of the District will exceed  $7\frac{1}{2}$  billion dollars. On this basis, the District will represent nearly half of the population of the State and a little less than half of the assessed valuation thereof.

About \$75,000,000 of construction work is under way or planned for the immediate future. For the longer range future Metropolitan expects to spend an additional \$120,000,000. Up to the present time the District has spent \$216,000,000 in bonds and taxes on construction. There remains to be paid, either as taxes or from water revenue, about \$500,000,000 for construction and bond retirement.

The District is the only public institution created to represent all of Southern California as a single unit. It is no longer in the expansion stage. It is a completely integrated unit capable of serving all of the coastal plain of Southern California. With a full realization of its responsibilities, the Board in 1952, adopted the following policy with regard to the importation and delivery of additional water supplies:

"The Metropolitan Water District of Southern California is prepared, with its existing



governmental powers and its present and projected distribution facilities, to provide its service area with adequate supplies of water to meet expanding and increasing needs in the years ahead. The District now is providing its service area with a supplemental water supply from the Colorado River. When and as additional water resources are required to meet increasing needs for domestic, industrial and municipal water, The Metropolitan Water District of Southern California will be prepared to deliver such supplies.

"Taxpayers and water users residing within The Metropolitan Water District of Southern California already have obligated themselves for the construction of an adequate supply and distribution system involving a cost in excess of \$350,000,000. This system has been designed and constructed in a manner that permits orderly and economic extensions and enlargements to deliver the District's full share of Colorado River water as well as water from other sources as required in the years ahead. Establishment of overlapping and paralleling governmental authorities and water distribution facilities to service Southern California areas would place a wasteful and unnecessary financial burden upon all of the people of California, and particularly the residents of Southern California."

When our growth absorbs all of the water available from the Colorado River Aqueduct, the Metropolitan Water District will be in a much better position to face the problem of seeking new sources of supply than the area was in 1927 when the Metropolitan Water District Act was passed by the Legislature. Not only is the District today prepared to take care of more than 4,000,000 additional people, but when those people have arrived, the District will be large enough and its assessed valuation great enough to more readily face its problems of future water supply than has been the case in the past. Those who choose to come to Southern California may come with the assurance that in this southwest desert country, water for them will be provided.



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